CLAIMS

1. A method of fabricating a metamaterial comprising:

providing a sample of engineered microstructured material comprising one or more voids and configured to transmit electromagnetic radiation;

providing a high pressure fluid comprising at least one functional material carried in at least one carrier fluid;

passing the high pressure fluid through the one or more voids; and

causing the functional material to integrate into the engineered microstructured material to form the metamaterial.

2. A method according to claim 1, in which the carrier fluid is in its supercritical phase.

3. A method according to claim 1, in which the high pressure fluid has a pressure of 1 MPa or above, or of 2.5 MPa or above, or of 5 MPa or above, or of 10 MPa or above, or of 25 MPa or above, or of 50 MPa or above, or of 100 MPa or above, or of 500 MPa or above, or of 1000 MPa or above, or of 2000 MPa or above.

4. A method according to any one of claims 1 to 3, in which the one or more voids have a length and a width such that the ratio of the length to the width is in the range 1:1 to 10:1, or 1:1 to 100:1, or 1:1 to 1000:1, or 1:1 to 10000:1, or 1:1 to 100000:1, or 1:1 to 10^6:1, or 1:1 to 10^7:1, or 1:1 to 10^8:1, or 1:1 to 10^9:1, or 1:1 to 10^{10}:1, or 1:1 to 10^{11}:1, or 1:1 to 10^{12}:1 or 10:1 to 100:1, or 10:1 to 1000:1, or 10:1 to 10000:1, or 10:1 to 100000:1, or 10:1 to 10^6:1, or 10:1 to 10^7:1, or 10:1 to 10^8:1, or 10:1 to 10^9:1, or 10:1 to 10^{10}:1, or 10:1 to 10^{11}:1, or 10:1 to 10^{12}:1 or 100:1 to 1000:1, or 100:1 to 10000:1, or 100:1 to 100000:1, or 100:1 to 10^6:1, or 100:1 to 10^7:1, or 100:1 to 10^8:1, or 100:1 to 10^9:1, or 100:1 to 10^{10}:1, or 100:1 to 10^{11}:1, or 100:1 to

10^{12}:1 or 1000:1 to 10000:1, or 1000:1 to 100000:1, or 1000:1 to 10^6:1, or 1000:1 to 10^7:1, or 1000:1 to 10^8:1, or 1000:1 to 10^9:1, or 1000:1 to 10^{10}:1, or 1000:1 to 10^{11}:1, or 1000:1 to 10^{12}:1 or 10000:1 to 100000:1, or 10000:1 to 10^6:1, or 10000:1 to 10^7:1, or 10000:1 to 10^8:1, or 10000:1 to 10^9:1, or 10000:1 to 10^{10}:1, or 10000:1 to 10^{11}:1, or 10000:1 to 10^{12}:1.

5. A method according to any preceding claim, in which the one or more voids have a width in the range 1 nm to 100 nm.

6. A method according to any one of claims 1 to 5, in which the sample of microstructured material is elongate and the one or more voids comprises one or more elongate holes running substantially the length of the sample of microstructured material.

7. A method according to claim 6, in which the sample of microstructured material comprises a holey optical fibre.

8. A method according to any one of claims 1 to 5, in which the sample of microstructured material is planar.

9. A method according to any one of claims 1 to 8, in which the one or more voids have a smallest dimension between 1 nm and 1 μm.

10. A method according to claim 9, in which the engineered microstructured material, the at least one functional material and dimensions of the one or more voids are selected to give a metamaterial that is a mesomaterial.

11. A method according to any one of claims 1 to 8, in which the one or more voids have a smallest dimension between 1 μm and 1 mm.

12. A method according to any preceding claim, in which the sample of microstructured material is fabricated from one or more of: glass materials, plastics materials, ceramic materials, semiconductor materials and metallic materials.

13. A method according to any preceding claim, in which the functional material comprises one or more of: metals, metal oxides, dielectric materials, superconductor materials, magnetic materials, ceramic materials, polymers, and biological materials.

14. A method according to any one of claims 1 to 13, in which causing the functional material to integrate into the engineered microstructured material comprises causing the functional material to deposit on a surface of the one or more voids.

15. A method according to claim 14, in which the functional material is deposited to form one or more nanoparticles on a surface of the one or more voids.

16. A method according to claim 14, in which the functional material is deposited to form an annular layer on a surface of the one or more voids.

17. A method according to claim 16, further comprising controlling the amount of functional material that is deposited to form an annular layer of a selected thickness.

18. A method according to claim 16 or claim 17, in which the annular layer comprises a thin film.

19. A method according to claim 17, in which the thickness of the annular layer is selected to reduce the width of the one or more voids to a selected size.

20. A method according to any one of claims 14 to 19, and further comprising providing a further high pressure fluid comprising a further functional material and passing the further high pressure fluid through the one or more voids to cause the further functional material to deposit on the functional material previously deposited.

21. A method according to claim 19, and further comprising providing a further high pressure fluid comprising a further functional material and passing the further high pressure fluid through the one or more voids to cause the further functional material to deposit on the functional material previously deposited, in which the selected size of the one or more voids is such as to cause quantum confinement in the deposited further functional material.

22. A method according to claim 14, in which the functional material is deposited on a surface of the one or more voids until the one or more voids is substantially filled with the functional material.

23. A method according to claim 14, in which the functional material is deposited to create one or more quantum structures.

24. A method according to any preceding claim, in which the one or more voids comprise two or more voids, and passing the high pressure fluid through the one or more voids comprises passing the high pressure fluid through one or some of the two or more voids.

25. A method according to any preceding claim, in which the one or more voids comprises two or more voids, the method further comprising blocking a first selection of one or some of the voids to prevent passing of the high pressure fluid so that integration of the functional material does not occur for the first selection of voids.

26. A method according to claim 25, and subsequently comprising blocking a second selection of one or some of the voids before passing a further high pressure fluid through the one or more voids, so that integration of the functional material does not occur for the second selection of voids.

27. A method according to claim 26, and subsequently comprising blocking further selections of one or some of the voids and passing further high pressure fluids until a desired metamaterial is achieved.

28. A method according to claim 26 or claim 27, in which the further high pressure fluid or fluids comprise a functional material or materials different from the said functional material comprised in the said high pressure fluid.

29. A method according to any one of claims 25 to 28, in which blocking one or some of the voids comprises covering openings of the voids with a mask material and using photolithographic patterning of the mask material to unblock a selected one or more voids.

30. A method according to any one of claims 25 to 28, in which blocking one or some of the voids comprises filling the one or some of the voids with a pressurised fluid.

31. A method according to any one of claims 24 to 29, and further comprising filling the one or more voids through which the high pressure fluid is not passed with an inert pressurised fluid to substantially equalise forces within the engineered microstructured material during passing of the high pressure fluid.

32. A method according to any one of claims 1 to 31, in which causing the functional material to integrate into the engineered microstructured material comprises heating the high pressure fluid as it passes through the one or more voids to cause the functional material to separate from the carrier fluid and integrate into the engineered microstructured material.

33. A method according to claim 32, comprising heating the high pressure fluid by heating selected portions of the sample for selected durations to control an amount of functional material that becomes integrated.

34. A method according to claim 32 or claim 33, in which heating the high pressure fluid comprises applying a temperature gradient along all or part of the sample.

35. A method according to claim 34, in which the temperature gradient is dynamically varying.

36. A method according to claim 34, in which the temperature gradient is static.

37. A method according to any one of claims 32 to 36, in which heating the high pressure fluid comprises heating a portion of the sample to create a heated zone, and moving the heated zone along the sample to integrate the functional material sequentially along all or part of the sample.

38. A method according to claim 37, and further comprising implanting a plug of alloy-forming material in the one or more voids before passing the high pressure fluid through the one or more voids, passing the high pressure fluid through the one or more voids and allowing an alloy to form from the functional material and the alloy-forming material in the heated zone, the alloy depositing the functional material in response to the heat.

39. A method according to any one of claims 1 to 39, in which causing the functional material to integrate into the engineered microstructured material comprises altering the pressure of the high pressure fluid as it passes through the one or more voids to cause the functional material to separate from the carrier fluid and integrate into the engineered microstructured material.

40. A method according to any one of claims 1 to 39, in which causing the functional material to integrate comprises applying a pressure gradient along all or part of the sample as the high pressure fluid is passed through the one or more voids.

41. A method according to any one of claims 1 to 40, in which causing the functional material to integrate comprises applying a gradient in concentration of the functional material in the high pressure fluid along all or part of the sample as the high pressure fluid is passed through the one or more voids.

42. A method according to any one of claim 1 to 41, in which causing the functional material to integrate into the engineered microstructured material comprises providing a carrier fluid that can diffuse through the engineered microstructured material, and allowing the carrier fluid to diffuse through walls of the one or more voids to leave the functional material within the one or more voids.

43. A method according to claim 42, in which the carrier fluid can further diffuse through the integrated functional material.

44. A method according to any one of claims 1 to 43, in which the functional material has a precursor form in the high pressure fluid, and causing the functional material to integrate comprises decomposing the precursor into the functional material and a by-product that can diffuse through the engineered microstructured material and allowing the by-product to diffuse through walls of the one or more voids.

45. A method according to any one of claims 1 to 44, in which causing the functional material to integrate into the engineered microstructured material comprises providing a functional material that will integrate into the engineered microstructured material when exposed to energy, and exposing the high pressure fluid to energy as it passes through the one or more voids.

46. A method according to claim 45, comprising exposing the high pressure fluid to a spatially varying pattern of energy to cause spatially varying integration of the functional material.

47. A method according to claim 45 or claim 46, comprising exposing the high pressure fluid to a temporally varying pattern of energy to cause spatially varying integration of the functional material.

48. A method according to any one of claims 45 to 47, in which the energy comprises electromagnetic radiation.

49. A method according to any one of claims 1 to 37 or claims 39 to 48, in which causing the functional material to integrate into the engineered microstructured material comprises providing a functional material that is a monomer, and providing conditions within the one or more voids under which the monomer polymerises while passing the high pressure fluid through the one or more voids to cause formation of a polymer within the one or more voids.

50. A method according to any one of claims 1 to 37 or claims 39 to 48, in which causing the functional material to integrate into the engineered microstructured material comprises providing a functional material that bonds with the engineered microstructured material when brought into contact by the carrier fluid.

51. A method according to any one of claims 1 to 37 or claims 39 to 48, in which causing the functional material to integrate into the engineered microstructured material comprises providing a functional material that will grow from a seed, and incorporating a seed into the one or more voids so that the functional material will grow within the one or more voids as the high pressure fluid passes through the one or more voids.

52. A method according to any preceding claim, in which causing the functional material to integrate comprises applying one or more integration-causing conditions to the sample that vary along a gradient over all or part of the sample.

53. A method according to any preceding claim and further comprising fabricating one or more further metamaterials using the method according to any preceding claim, and bonding the metamaterials together to create a final metamaterial.

54. A method according to claim 53, in which at least two of the metamaterials are different.